Ultra-Short Baseline Positioning System for Littoral Swarm Systems

Chris Casey
IS Robotics, Inc.
22 McGrath Highway, Suite 6
Somerville, MA 02143
Phone: (617) 629-0055 Fax: (617) 629-0126 E-mail: cmcasey@isr.com
http://www.isr.com

Dr. Henrik Schmidt
MIT Ocean Engineering
Phone: (617) 253-5727 Fax: (617) 253-2350 E-mail: henrik@keel.mit.edu

Contract #: N0001498C0230

LONG-TERM GOAL

The long-term goal of the Distributed Acoustic Mobile Positioning (DAMP) program is to develop a positioning system for use in littoral regions. The system will operate in a variety of conditions and will form the cornerstone of a multi-vehicle positioning and navigation system.

OBJECTIVES

We seek to implement such a system using an ultra-short baseline (USBL) positioning system to provide bearing information along with a round-trip time-of-flight measurement protocol to provide range information. In order to be useful for the systems contemplated (swarms of robots), such a system must be inexpensive, small, lightweight, and energy efficient. Characterization of the surf zone (SZ) acoustic environment will be necessary in order to effectively select operating parameters such as frequency and intensity of the USBL system. However the main objective of DAMP is to create a workable and working USBL system operable in the very shallow water (VSW) and SZ environments. One application of this technology is to VSW/SZ mine remediation.

APPROACH

Key personnel include:

- Dr. Henrik Schmidt, Associate Department Head, Department of Ocean Engineering, MIT. Dr. Schmidt is overseeing the VSW/SZ characterization effort.
- Chris Casey, Lead Electrical Engineer, IS Robotics, Inc. Mr. Casey is Principal Investigator at IS Robotics, Inc. (ISR) for the DAMP program.
- Misha Filippov, Senior Electrical Engineer, IS Robotics, Inc. Mr. Filippov is responsible for the design of the electronics used in the DAMP system.
- David Sotkowitz, Senior Software Engineer, IS Robotics, Inc. Mr. Sotkowitz is responsible for software design for the DAMP program.

Our general approach has been to make use of cheap microprocessors and programmable logic in order to maximize flexibility. The use of these devices is designed to allow us to implement a system in which nearly all significant parameters (ping frequency, intensity, and duration, range estimation protocol, etc.) can be easily varied – often at run-time.

WORK COMPLETED

Work in the previous year has concentrated on integration of the system components and modules that have been previously designed and fabricated, and on developing software. Once this has been completed, we intend to use the system to investigate operating parameters suitable for use in various terrains and for different missions.

Two DAMP systems have been fabricated. A test facility has been constructed at ISR to allow testing of signal propagation underwater and to permit test and characterization of different filtering and computation strategies.

The DAMP system is implemented as five modules:

- Front-End Amplification and Filtering
- Frequency Detection
- Phase Detection
- Transmitting
- Host Interface

These modules are implemented on two PCBs, one containing the Front-End Amplification and Filtering module, the other containing the remaining four. A separate PIC micro-controller is used to control the Frequency Detector, Phase Detector, Transmitter, and Host Interface. Each of the subsystems in the DAMP system was tested separately last year, with some integration effort also occurring. Work this year has focused on finishing integration and tuning detection and filtering algorithms for real-world use.

In the course of integration, we discovered that inter-processor communication between the various modules is consuming much more processing power than had been anticipated. In addition, the tight timing requirements between the processors and the lack of appropriate debugging tools have hampered debug efforts.

In order to minimize the impact of interprocessor communication requirements, and to relax timing constraints between the modules as much as possible, significant effort has had to be expended to make frequency and phase detection processing as efficient as possible, and to reduce the demands of interprocessor and host communication. In general, this has resulted in the need to implement significantly more code in assembly language than had originally been contemplated.

In order to reduce the demands on the processing of frequency discrimination, the range of tones that the system is capable of discriminating was changed from ten tones equally spaced in the range 24.4KHz to 25.6KHz (25±0.6KHz) to ten tones equally spaced in the range 24.15KHz to 25.85KHz

(25±0.85KHz). This required a corresponding change in the input filtering section to accommodate the new wider input range. The wider separation between tones allows greater tolerance on the part of the frequency detector.

Work is continuing on software development, with electronics effort moving to a support/maintenance role. Once integration has been completed, and successful testing at ISR's facility performed, we will be conducting additional testing at MIT's wave tank facility in order to further refine filtering and detection algorithms. The final step will be to conduct testing in ocean environments using additional systems.

IMPACT/APPLICATIONS

The development of a cheap relative navigation system as here envisioned would enable the implementation of swarm behaviors in underwater robots. This has application in a variety of areas, ranging from mine clearance to physical survey and mapping.

RELATED PROJECTS

None ongoing.